Atomic Structure Review

Element Name

Calcium - 42

Mass Number (P+N)

Mass Number (P+N)

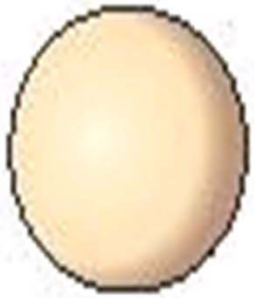
$^{42}_{20}Ca^{2+}$

Charge (P vs. E)

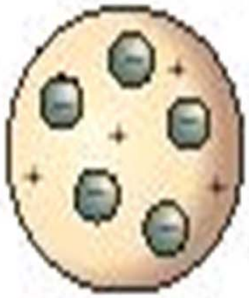
Atomic Number (P)

Element Symbol

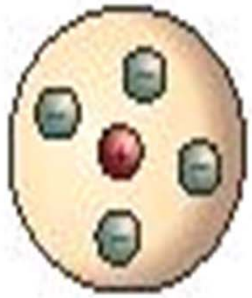
Dalton's atom



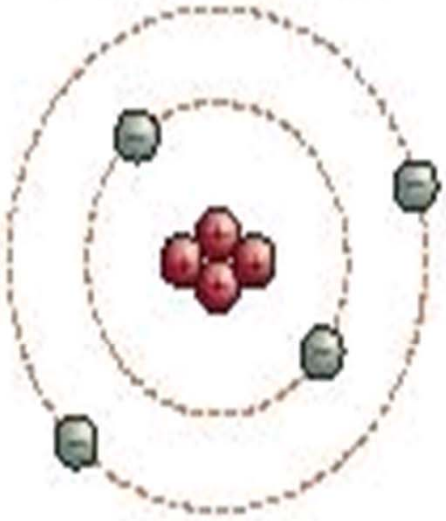
Thomson's plum-pudding atom



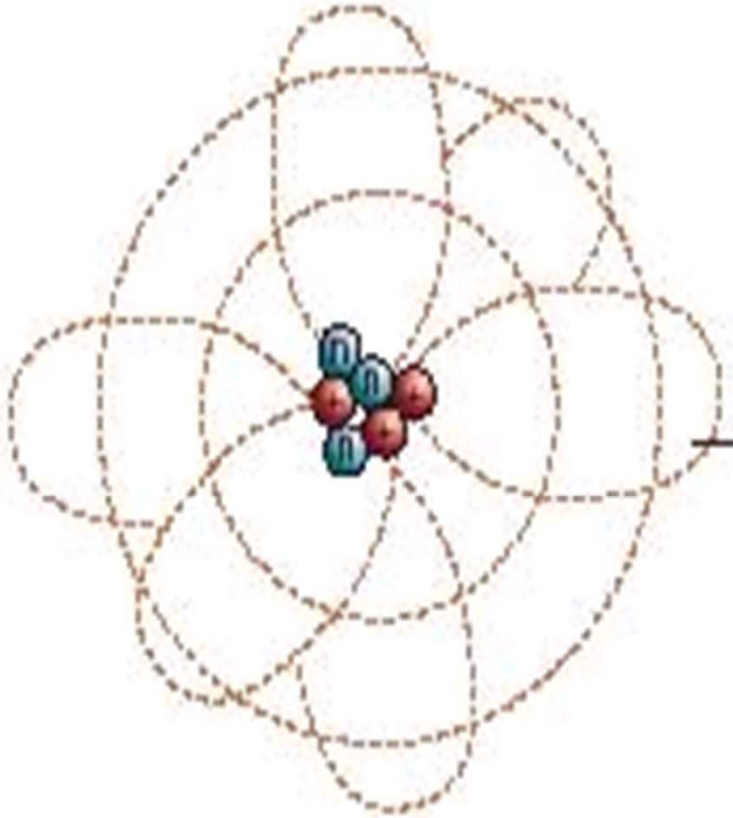
Rutherford's atom



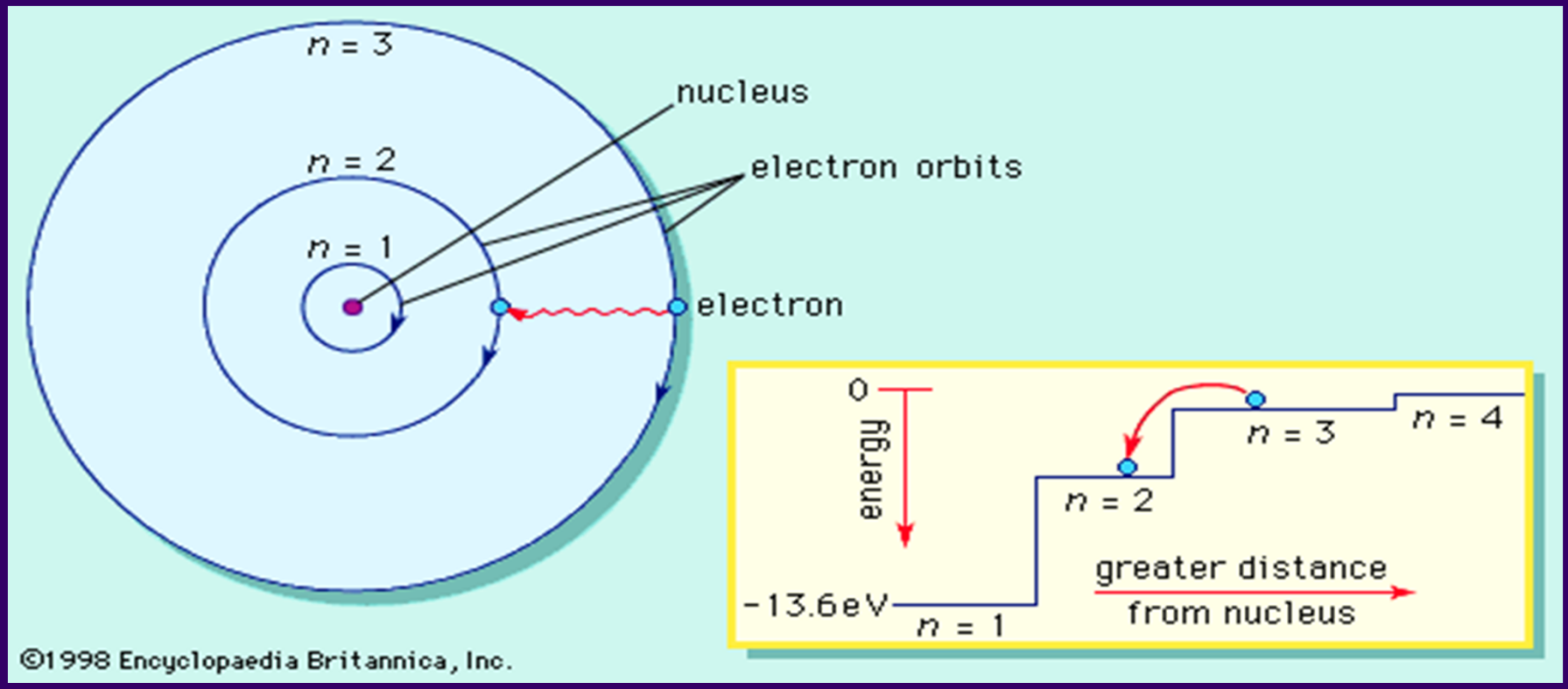
Bohr's planetary atom



Current orbital atom



Bohr Model of the Atom:



Modern Quantum theory

- Electrons exist in regions or zones
- Those zones have sublevels

What is Quanta?

Energy Levels:

_____ n=5 (highest)

_____ n=4

_____ n=3

_____ n=2

_____ n=1 (lowest)

Quantum – amount of energy required to move an electron from energy level to energy level

Energy levels become closer

Principle Energy Levels (n)

Principle quantum numbers (n) correspond to rows in Periodic Table

- n = 1, 2, 3, 4, etc

- In order of increasing energy levels

Atomic Orbitals → s, p, d, f

s (1) (total 2e- fit)

Alkali Metals and Alkaline Earths

p_x, p_y, p_z (3) (total 6e- fit)

Representative Elements

d_{xy}, d_{xz}, d_y^2, d_x^2, $d_x^2y^2$, d_z^2 (5) (total 10 e- fit)

Transition Metals

f (7) (total 14e-)

Lanthanides and Actinides

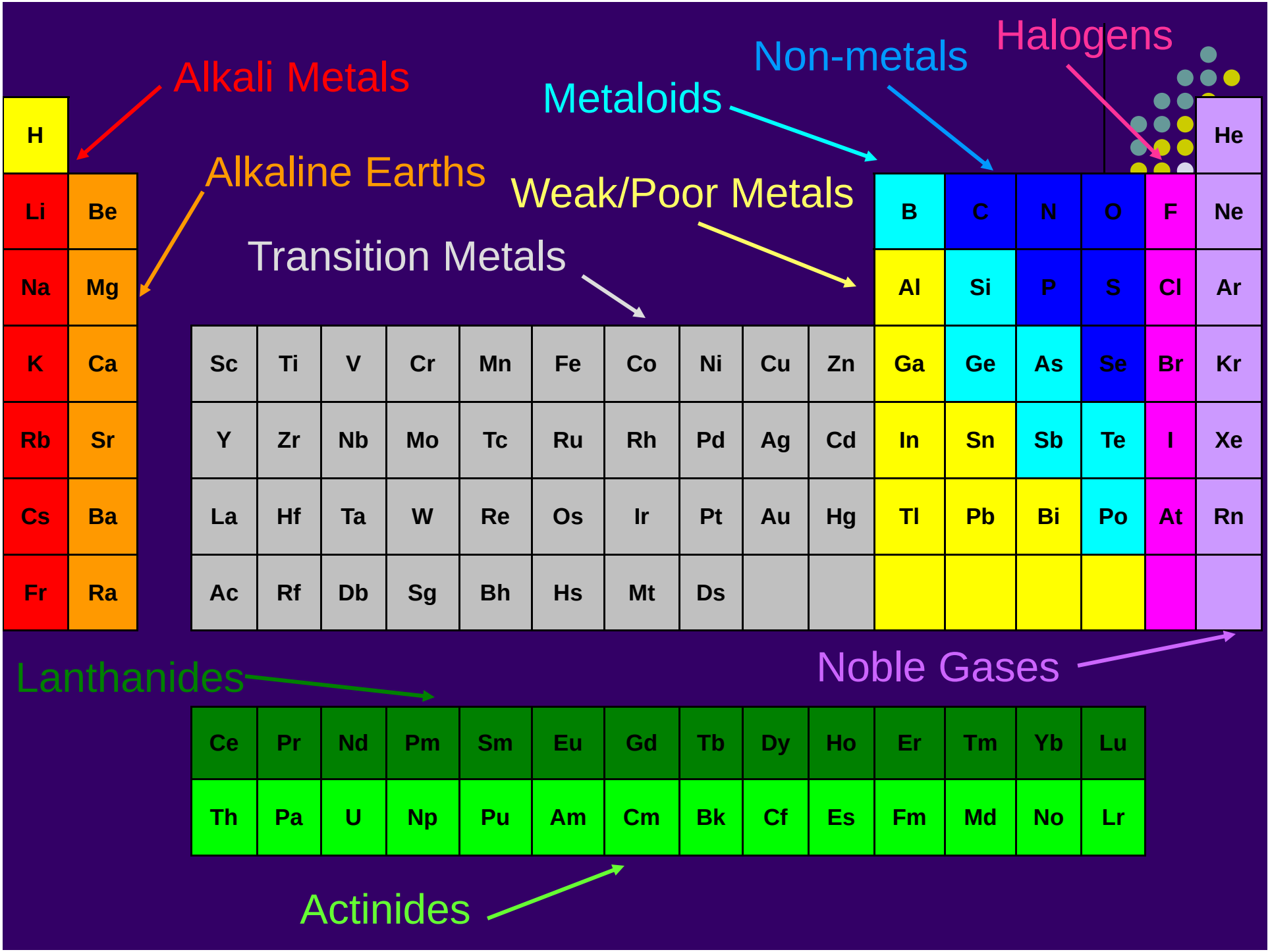
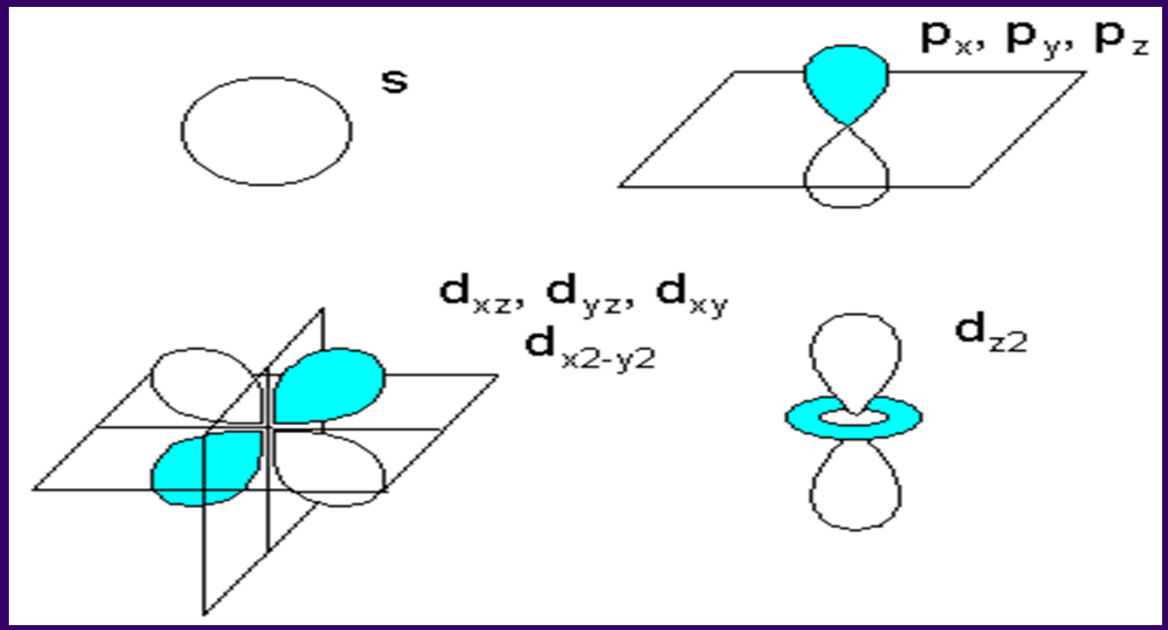

Alkali Metals
Alkaline Earths
Transition Metals
Metaloids
Non-metals
Halogens
Weak/Poor Metals
Lanthanides
Actinides
Noble Gases
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
Cu
Zn
Ga
Ge
As
Se
Br
Kr
Rb
Sr
Y
Zr
Nb
Mo
Tc
Ru
Rh
Pd
Ag
Cd
In
Sn
Sb
Te
I
Xe
Cs
Ba
La
Hf
Ta
W
Re
Os
Ir
Pt
Au
Hg
Tl
Pb
Bi
Po
At
Rn
Fr
Ra
Ac
Rf
Db
Sg
Bh
Hs
Mt
Ds
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
Th
Pa
U
Np
Pu
Am
Cm
Bk
Cf
Es
Fm
Md
No
Lr

Diagram of s, p, and d orbitals



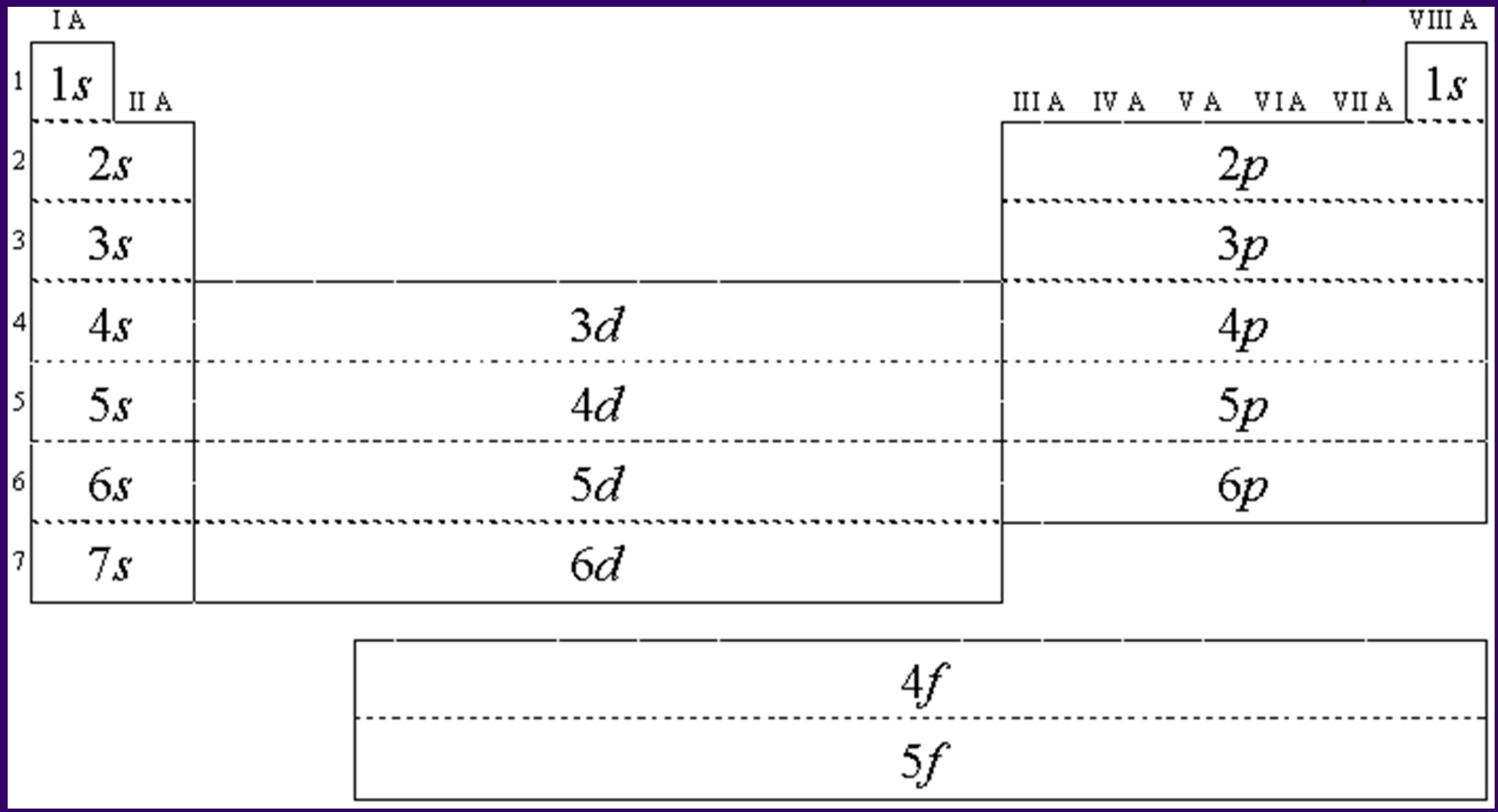
Electron Orbital Shapes:

http://winter.group.shef.ac.uk/orbitron/ great visual for the 3D nature of electron orbitals. Provides clear images of everything from the 1s orbital to hybridized orbitals.

Summary of Principle Energy Levels (n), Sublevels (ℓ), and Orbitals (m_ℓ)

Principle Energy Level	Number of Sublevels	Type of Sublevels
n = 1	1	1s (1 orbital)
n = 2	2	2s (1 orbital), 2p (3 orbital)
n = 3	3	3s (1 orbital), 3p (3 orbital), 3d (5 orbital)
n = 4	4	4s (1 orbital), 4p (3 orbital), 4d (5 orbital), 4f (7 orbital)

Periodic Table with Quantum Numbers



Electron Configurations

The ways which electrons are arranged around the nuclei or atoms

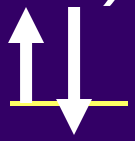
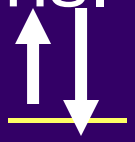
- Fill from lowest principle energy level to highest
- Fill in one sublevel before next
- 2 electrons fill an orbital

3 Rules for Orbital Box Diagrams

Aufbau Principle – electrons enter orbitals of lowest energy first

- 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p

Pauli Exclusion Principle - An atomic orbital may describe at most 2 electrons with opposite (anti-parallel) spins.

- 1s  2s  2p 

Hund's Rule – When electrons occupy orbitals of equal energy, one electron enters each orbital until all orbitals contain one electron with parallel spins

- 1s  2s  2p 

Aufbau Principle

_ _ _ 7p _ _ _ _ _ 6d _ _ _ _ _ _ _ _5f

_7s

_ _ _ 6p _ _ _ _ _ _5d _ _ _ _ _ _ _ _4f

_6s

_ _ _5p _ _ _ _ _ 4d

_5s

_ _ _4p

_4s _ _ _ _ _3d

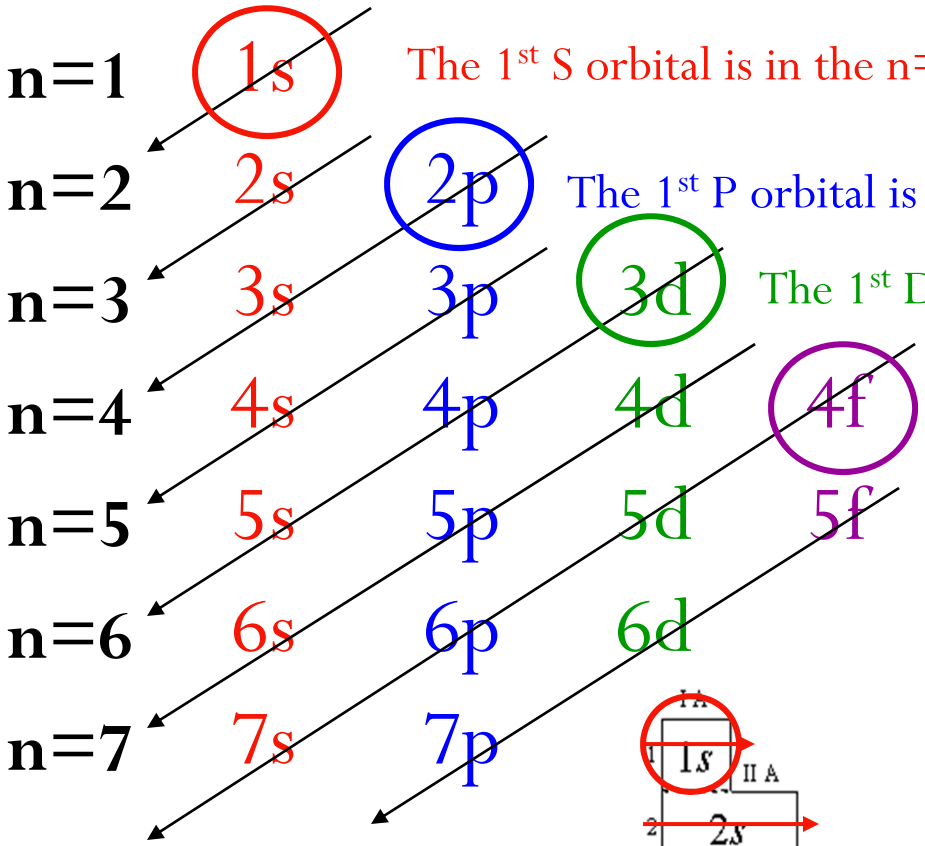
_ _ _3p

_3s

_ _ _2p

_2s

_1s



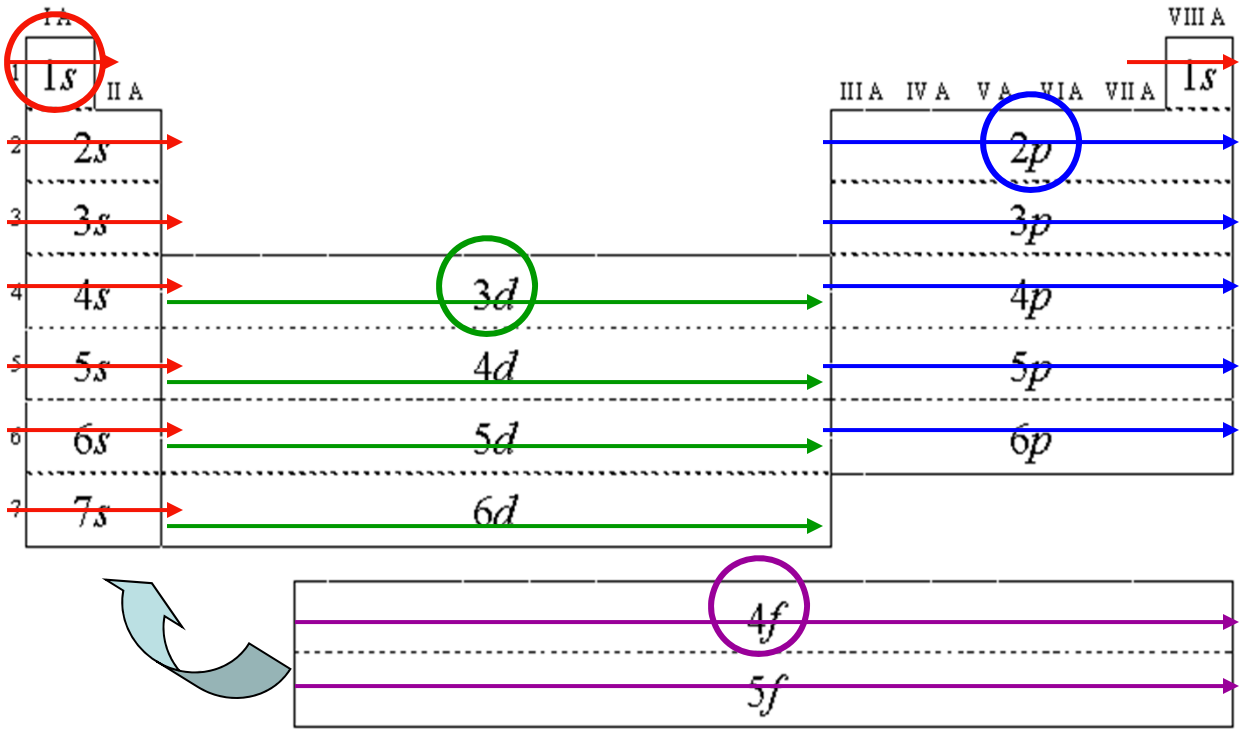
The 1st S orbital is in the n=1 energy level

The 1st P orbital is in the n=2 energy level

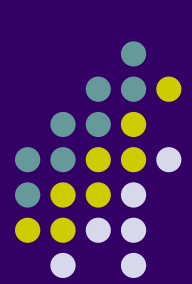
The 1st D orbital is in the n=3 energy level

The 1st F orbital is in the n=4 energy level

Filling Order of Orbitals



Electron Configuration Notation



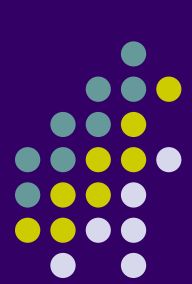
$4s^1$

4 tells us the Principle Energy Level (n) or Row on the periodic table

s tells us the Sublevel's Shape (ℓ) or block on the periodic table

1 tells us the Number of electrons in that sublevel (m_ℓ) or the Column within the block on the Periodic table

Spectroscopic Notation
Full electron Configuration



Read periodic table like a book (left to right, top to bottom)

Once a sublevel is filled right is down and move to next sublevel

Helium (Z=2) $1s^2$

Lithium (z=3) $1s^2 2s^1$

Scandium (Z=21) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

Condensed or Abbreviated Notation (also called Noble gas notation)

1. Find previous noble gas before element
2. Write symbol of noble gas in brackets and write any remaining sublevels after it

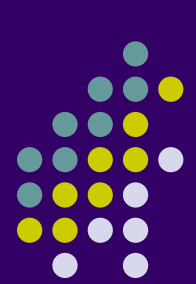
Lithium (Z=3) Full = $1s^2 2s^1$

Abbr. = [He] $2s^1$

Sc (Z=21) Full = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

Abbr. = [Ar] $4s^2 3d^1$

Electron Configuration for ions



Magnesium +2 (lost 2e-, now only has 10e-)

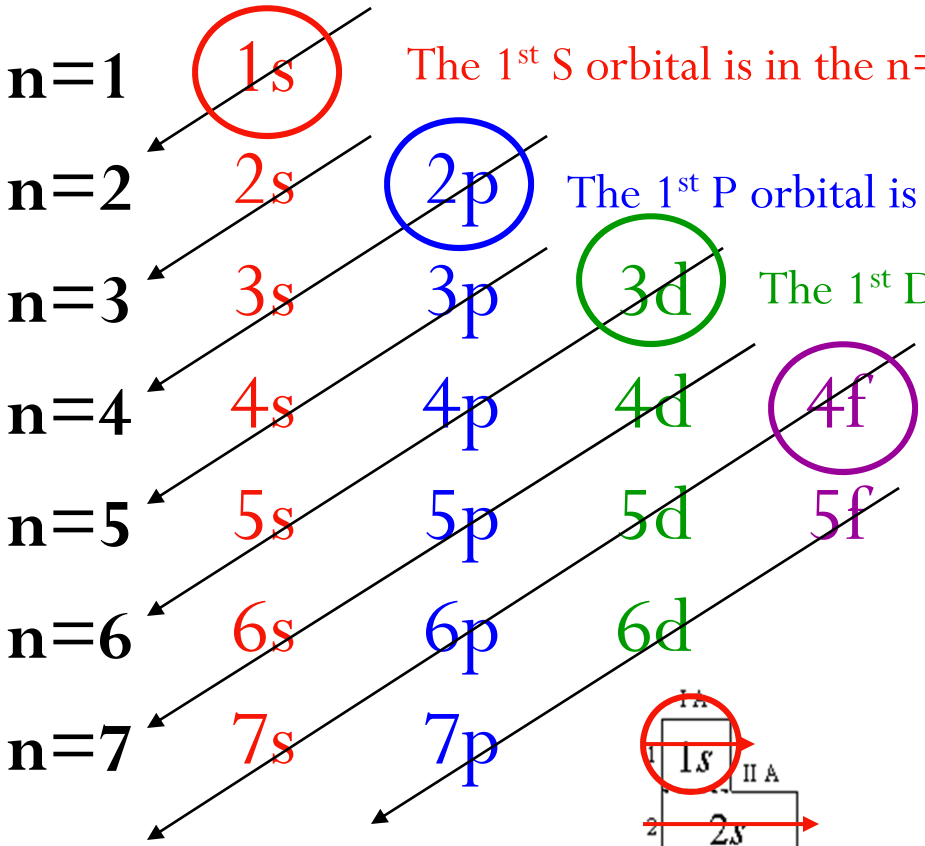
Mg^{+2} $1s^2\ 2s^2\ 2p^6$

Iron +3 (lost 3 e-, now only has 23e-)

Fe^{+3} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$

Chlorine (gained 1e-, now has 18e-)

Cl^{-1} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$



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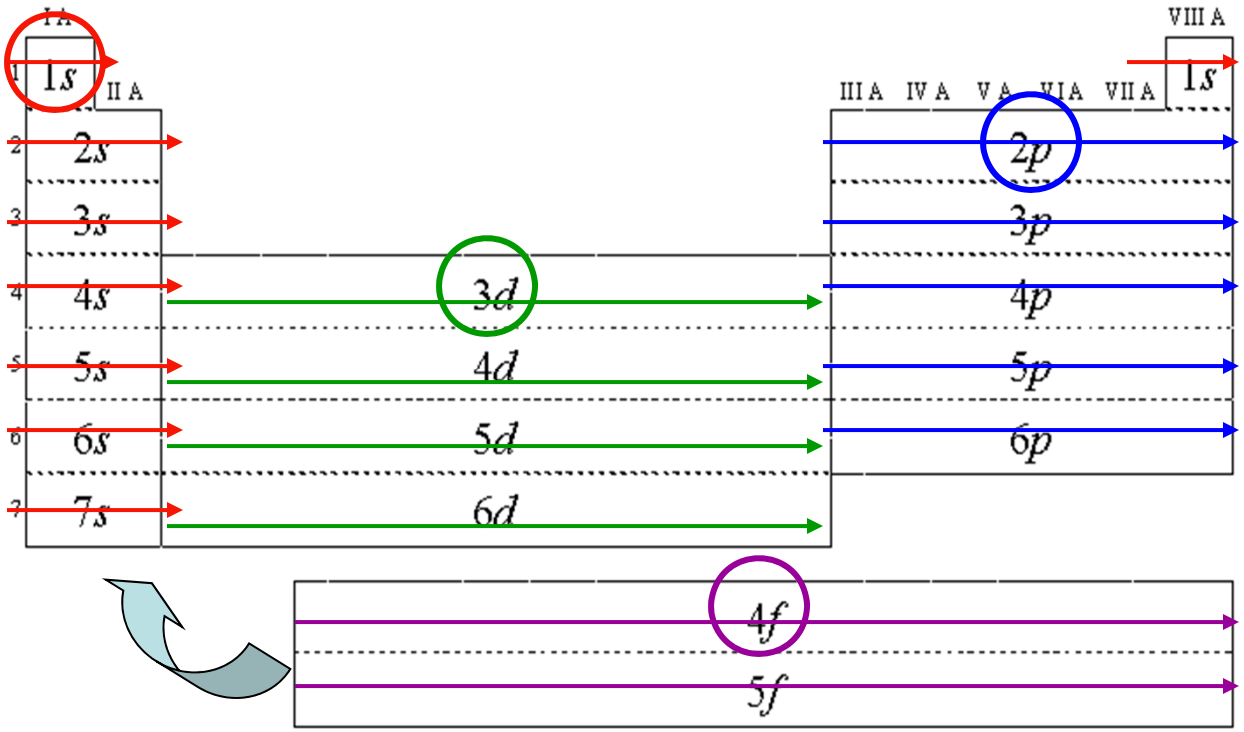

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- **Orbital Box Diagrams:**
- http://acswebcontent.acs.org/games/pt.html see the electron configuration tab to demonstrate Hunds, Pauli, and Aufbau Principles.

An Extension of Hunds Rule:

Sometimes the d-orbital may steal an electron from the preceding s-orbital to make all "half-filled"